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The experience with bundle branch block at the USAF School of Aerospace Medicine was reviewed. The clinical and follow-up status was evaluated in 394 subjects with right bundle branch block (RBBB) and 125 subjects with left bundle branch block (LBBB). Most subjects were asymptomatic at the time of bundle branch block diagnosis. The subjects were divided into electrocardiographic (ECG) subgroups to determine if any one subgroup was at higher risk for initial or follow-up morbidity of cardiovascular disease or follow-up mortality. At initial diagnosis and clinical evaluation, 94% of RBBB subjects and 89% LBBB subjects had no

Block 20 (Continued)

evidence of cardiovascular disease. In the RBBB group, 3% and 2% had coronary heart disease and hypertension respectively; in the LBBB 9% and 7%. No one ECG subgroup in either the RBBB or LBBB group had a higher incidence of cardiovascular disease. Complete follow-up information was available in 94% and 91% of the RBBB and LBBB subjects respectively. The mean follow-up period was 10.8 ± 4.7 years in the RBBB group and 8.8 ± 4.8 in the LBBB group. In the follow-up period, new cases of coronary heart disease and hypertension occurred in 6% of the RBBB group and 5% and 8%, respectively, in the LBBB group. Fourteen (4%) RBBB and 9 (8%)LBBB subjects expired during the follow-up period. No differences for follow-up morbidity of cardiovascular disease or mortality were observed in contrasting the individual ECG subgroups.

A Clinical and Follow-up Study of Right and Left Bundle Branch Block

By Michael Rotman, Major, USAF, MC, and John H. Triebwasser, Colonel, USAF, MC

SUMMARY

The experience with bundle branch block at the USAF School of Aerospace Medicine was reviewed. The clinical and follow-up status was evaluated in 394 subjects with right bundle branch block (RBBB) and 125 subjects with left bundle branch block (LBBB). The majority of subjects were asymptomatic at the time of bundle branch block diagnosis. The subjects were divided into subgroups based on electrocardiographic (ECG) findings to determine if any one subgroup was at higher risk for initial or follow-up morbidity of cardiovascular disease or follow-up mortality. At initial diagnosis and clinical evaluation, 94% of RBBB and 89% of LBBB subjects had no evidence of cardiovascular disease. In the RBBB group, 3 and 2% had coronary heart disease and hypertension, respectively; in LBBB subjects, 9 and 7% had coronary heart disease and hypertension, respectively. No one ECG subgroup in either the RBBB or LBBB group had a higher incidence of cardiovascular disease. Complete follow-up information was available in 94% of the RBBB subjects and 91% of the LBBB subjects. The mean follow-up period was 10.8 ± 4.7 years in the RBBB group and 8.8 ± 4.8 in the LBBB group. In the follow-up period, new cases of coronary heart disease and hypertension occurred in 6% of the RBBB group and 5 and 8%, respectively, in the LBBB group. Fourteen (4%) RBBB and nine (8%) LBBB subjects died during the follow-up period. No differences for follow-up morbidity of cardiovascular disease or mortality were observed in contrasting the individual ECG subgroups. Progressive electrical dysfunction in the form of complete heart block occurred in one subject each in the RBBB and LBBB groups. Thus the prognosis of bundle branch block is determined by the presence or absence, and degree of associated cardiovascular disease. Furthermore, within the age limits of the present study, significant progressive electrical dysfunction is a rare occurrence. The prognosis, etiology, and aeromedical implications of bundle branch block are discussed.

Additional Indexing Words:
Sudden death   Flying status

THE CONCEPT OF BUNDLE BRANCH BLOCK was introduced over 60 years ago by Eppinger and Rothberger in Vienna.[1] A wealth of literature related to the anatomy, electrophysiology, and clinical and prognostic significance of bundle branch block has accumulated since their original paper. The most recent concept, proposed by Rosenbaum and his associates, of a trifascicular bundle branch conduction system, is clinically useful for diagnosis and prognosis.[2,3]

There is little agreement in the literature about the prognostic significance of bundle branch block.[4-16] Several factors account for the differing results obtained in several other follow-up studies: different criteria in selecting patients, based on the electrocardiographic diagnosis of bundle branch block; dissimilar methods of grouping and presenting the available data; and most important, the population base from which the electrocardiograms are obtained. Since most previous studies have studied the pattern in patients with overt disease, this last factor becomes important when attempts to compare and contrast the presence of bundle branch block in a clinically ill population to that in an asymptomatic group are made.

The present study reviews the experience with patients with bundle branch block at the USAF School of Aerospace Medicine (USAFSAM). The purpose of the study was to group subjects with bundle branch block into various fascicular combinations and to compare and contrast these subgroups with regard to their clinical evaluation and follow-up status. A further comparison was made between the group with right bundle branch block (RBBB) and the group with left bundle branch block (LBBB).

Methods

The USAF Central Electrocardiographic Library was established at USAFSAM in April 1957. The purpose of the library is to obtain and collect electrocardiograms (ECG) on all USAF rated flying personnel and all applicants for flying or navigator training. The ECG library contains tracings on over 237,000 individuals. The Aeromedical Consultation Service at USAFSAM evaluates all flying personnel with medical problems. Most aircrew members referred for evaluation are asymptomatic; a large proportion is referred because of ECG abnormalities.

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In the present study, all ECGs referred to the ECG library with a diagnosis of RBBB or LBBB during the years 1957 through 1972 were reviewed. The ECGs were derived from a heterogeneous group of routine initial ECGs on individuals less than 30 years of age (including a mixed group of Air Force Academy cadets and applicants for flying training) and serial ECGs on rated flying personnel taken throughout their Air Force career.

Standard ECG criteria were used for diagnosing RBBB and LBBB.[17] Left anterior hemiblock (LAH) was diagnosed according to the criteria of Rosenbaum et al.[2, 3] and included the following: 1) a mean QRS axis of ≧ −45°, 2) small Q waves present in leads I and aV_L with a Q_1S_3 pattern, 3) normal or slight prolongation of QRS duration. Simple left axis deviation (LAD) was diagnosed when the mean QRS axis was ≧ −30° in the absence of criteria for LAH. Since the diagnosis of left posterior hemiblock is based on a combination of clinical and ECG criteria,[2, 3] this diagnosis could not be justified in our retrospective analysis of the clinical evaluation. Thus, the cases with right axis deviation (RAD) were divided into two groups; RAD > +120° and RAD of +90° to +120°. The diagnosis of 1° atrioventricular block (AVB) was made when the P-R interval was ≧ 0.22 sec.

In the majority of individuals, USAFSAM carried out the initial clinical evaluation at the time of diagnosis of RBBB or LBBB. This evaluation included a history, physical examination, routine ECG, vectorcardiogram, and radiographic examination of the chest. Laboratory evaluation included a glucose tolerance test and determinations of serum cholesterol and triglycerides. The Double Master's and treadmill exercise tests were used in exercise studies. Furthermore, 54 subjects with RBBB and 29 with LBBB had a complete cardiac catheterization, including selective coronary angiography.

The follow-up study was accomplished using health records, questionnaires, and direct telephone communications. The population that was critically examined included only those subjects that had had either an initial clinical evaluation and/or available complete follow-up information.

The data was analyzed for statistical significance by the biostatistics division at the School of Aerospace Medicine.

Results

Age Analysis

From over 237,000 subjects with ECGs in the ECG library during 1957–1972, a diagnosis of RBBB was made in 394 individuals and of LBBB in 125. The age range at time of diagnosis of the RBBB group was 17 to 58 years, with a mean age of 36 ± 9 years. The LBBB group had an age range of 20 to 56 years, with a mean age of 40 ± 7 years (fig. 1). A significantly higher percentage of younger individuals (< 25 years old) was observed in the RBBB group, while a higher percentage of older individuals (> 45 years old) was noted in the LBBB group ($P < 0.001$).

An analysis of variance was performed to determine if a significant difference in age was present between the ECG subgroups discussed below. In the RBBB group there were significant differences between the mean ages ($P < 0.01$) of the subgroup with normal axis (mean age of 34 ± 8 years) and the subgroup with RAD of +90° to +120° (mean age 31 ± 8 years). No other differences were observed. In the LBBB group, no significant differences were observed on age analysis between the three ECG subgroups.

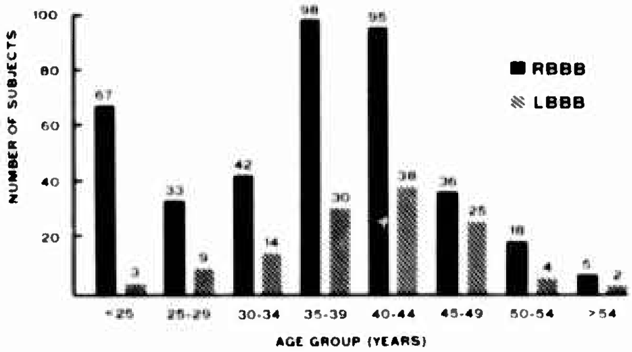

Figure 1

Age distribution at time of bundle branch block diagnosis. RBBB in dark bars, LBBB in hatched bars. A significant difference ($P < 0.001$) was observed in contrasting the two groups.

Electrocardiographic Analysis

The ECG subgrouping of subjects with RBBB is represented in table 1. A normal QRS axis was observed in 238 subjects (61%). An indeterminate axis was diagnosed in 45 subjects (11%). Right axis deviation was noted in 76 subjects, with 59 (15%) having a RAD of +90° to +120° and 17 (4%) with RAD of 120°. Simple LAD was observed in 8 (2%) subjects, while LAH was present in 20 (5%) subjects. In seven cases, 1° AVB was diagnosed, and five of these seven cases also had RAD +90° to +120°. Table 2 presents the ECG subgrouping analysis in those subjects with LBBB. In these individuals, 97 (78%) had normal QRS axis, 25 (20%) had left axis deviation (> −30°), and three (2%) had 1° AVB.

In the ECG evaluation, a diagnosis of RBBB was present on the first available ECG in 251 of the 394 cases. In the remaining 143 cases (37%), at least two ECGs without bundle branch block were available prior to the development of RBBB. In evaluating the

Table 1

Electrocardiographic Subgroup Analysis in 394 RBBB Subjects

Subgroup	Number	Percent
Normal axis	238	61
Indeterminate axis	45	11
Right axis <120°	59	15
Right axis >120°	17	4
Simple left axis	8	2
Left anterior hemiblock	20	5
1° A-V block	7	2
	394	100

Table 2

Electrocardiographic Subgroup Analysis in 125 LBBB Subjects

Subgroup	Number	Percent
Normal axis	97	78
Left axis deviation	25	20
1° A-V block	3	2
	125	100

LBBB group, 44 of 125 cases had the ECG pattern of LBBB present on the first available ECG. In 81 (65%) cases, LBBB was known to have been acquired on the basis of sampling serial yearly ECGs.

Clinical Analysis

Of the total 394 subjects with RBBB, 372 had a complete clinical evaluation at the time of diagnosis; 97% were completely asymptomatic at the time of clinical evaluation. A normal cardiovascular evaluation was present in 348 subjects (94%). Ten subjects (3%) had coronary heart disease: one had had a previous myocardial infarction, six had clinical evidence of coronary disease based on classic exertional chest discomfort, and three were asymptomatic but on selective coronary angiography had a greater than 50% obstruction of at least one major coronary artery. There were nine cases (2%) of mild to moderate hypertensive vascular disease, based on frequent blood pressure measurements with averaged levels greater than 140/90 mm Hg. Other forms of cardiovascular disease included five cases of congenital heart disease (three with atrial septal defects, one with a patent ductus arteriosus, and one with coarctation of the aorta and aortic stenosis), one case of rheumatic heart disease with mild mitral and aortic insufficiency, one case of documented myocarditis, and two cases of nonrheumatic hemodynamically insignificant mitral insufficiency. Since some of the ECG subgroups contained a small number of subjects, statistical testing comparing the subgroups was not performed; however, no individual ECG subgroup appeared to have a higher incidence of cardiovascular disease at the time of RBBB diagnosis (table 3).

Table 3

Subgroup Analysis of Clinical Evaluation in RBBB Subjects

	Total	Normal N	CHD N	HVD N
Normal axis	228	214	6	4
Indeterminate axis	41	40		1
Right axis <120°	56	51	3	2
Right axis >120°	16	15		1
Simple left axis	6	6		
Left anterior hemiblock	18	16		1
1° A-V block	7	6	1	
N	372	348	10	9
(%)		(94)	(3)	(2)

Abbreviations: N = number; CHD = coronary heart disease; HVD = hypertensive vascular disease.

Of the total 125 cases with LBBB, 121 had a complete cardiovascular evaluation at the time of diagnosis; 95% of the cases were asymptomatic. A normal evaluation was present in 101 subjects (89%). Eleven (9%) had coronary heart disease (seven on clinical evaluation and four by significant obstructive disease noted on coronary angiography), and eight (7%) had mild to moderate hypertension. One case each of rheumatic heart disease and of idiopathic cardiomyopathy were also observed. No ECG subgroup appears to have a higher incidence of cardiovascular disease (table 4).

In contrasting the initial clinical evaluation of the group with RBBB versus LBBB, a significantly higher number of cases of coronary heart disease ($P < 0.01$) and hypertension ($P < 0.05$) were observed in the LBBB group. This difference was not influenced by age factors since contrasting the two groups by age stratification still yielded significant differences.

Follow-up Evaluation

Complete follow-up information to June 1973 was available in 372 (94%) of the 394 cases with RBBB. The remaining 22 cases were proportionally distributed in the varied ECG subgroups: 12 RBBB with normal axis; four RBBB with indeterminate axis; five RBBB and RAD; and one RBBB and simple LAH. Fourteen of the subjects lost to follow-up were less than 30 years old at the time of RBBB diagnosis, and 21 subjects were less than 40 years of age. The mean follow-up period of the RBBB group was 10.8 ± 4.7 years: 16% of the total group was followed for over 15 years; 57% over 11 years; 27% from six to ten years; and 16%, for less than six years.

In the LBBB group, 114 (91%) had complete follow-up information. In the remaining 11 cases, seven had LBBB with normal QRS axis and four had

Table 4

Subgroup Analysis of Clinical Evaluation in LBBB Subjects

	Total	Normal N	CHD N	HVD N
Normal axis	93	80	10	3
Left axis deviation	25	18	1	5
1° A-V block	3	3	—	—
N	121	101	11	8
(%)		(89)	(9)	(7)

See table 3 for abbreviations.

LBBB with left axis deviation. Three subjects lost to follow-up were less than 30 years old at time of LBBB diagnosis. The mean follow-up period was 8.8 ± 4.8 years: 9% of the total group was followed for over 15 years; 36% over 11 years; 32% from six to ten years; and 32% for less than six years.

The mean age at time of follow-up in the RBBB group was 47 ± 10 years with an age range of 18 to 70 years. The mean age in the LBBB group was 49 ± 7 years with an age range of 29 to 66 years (fig. 2).

In the RBBB group during the follow-up period, 21 (6%) new cases of coronary heart disease and 21 (6%) new cases of hypertension developed; 14 (4%) patients died. No one ECG subgroup appeared to be at higher risk for follow-up morbidity of heart disease or mortality (table 5).

In the LBBB group, six (5%) new cases of coronary heart disease and seven (6%) new cases of hypertension developed; nine (8%) subjects died. Two new cases of symptomatic idiopathic cardiomyopathy developed during the follow-up period. No ECG subgroups seemed to be at higher risk for follow-up morbidity or mortality (table 6).

In contrasting the follow-up data on the RBBB and LBBB groups by age stratification, no significant differences were observed with regard to morbidity or mortality.

During the follow-up period for the ten subjects in the RBBB group with coronary heart disease diagnosed at the time of the initial evaluation, six were asymptomatic, one had angina pectoris, one had a nonfatal myocardial infarction, and two had died (one of an acute myocardial infarction and one with chronic lung disease and cor pulmonale). Of the nine RBBB subjects with an initial diagnosis of hypertension, seven were asymptomatic, one had congestive heart failure and angina pectoris, and one died of an acute myocardial infarction.

During the follow-up period for the 11 subjects in the LBBB group with coronary heart disease diagnosed at the time of initial evaluation, seven were asymptomatic, one had angina pectoris, one had expired from an acute myocardial infarction, one was lost to follow-up, and one had an acute myocardial infarction during which complete heart block developed and necessitated permanent pacemaker implantation. Of the eight LBBB subjects with an initial diagnosis of hypertension, three were asymptomatic, one had congestive heart failure and angina pectoris, one was lost to follow-up, and three subjects expired (one, of an acute myocardial infarction; one, of complications of cardiac catheterization; one of unknown causes).

The cause of death, as well as other relevant parameters in the 14 RBBB patients who died, is presented in table 7. In eight subjects the cause of death was accidental; three died in aircraft accidents related to bad weather, three died in automobile accidents, one fell off a scaffold, and one died of accidental carbon monoxide poisoning. Two subjects died of pump failure during an acute myocardial infarction, one died of chronic lung disease complicated by cor pulmonale, and for one, the cause of death was not available.

Of the nine LBBB patients who died, five died of conditions related to coronary heart disease: one suddenly with a previous diagnosis of idiopathic car-

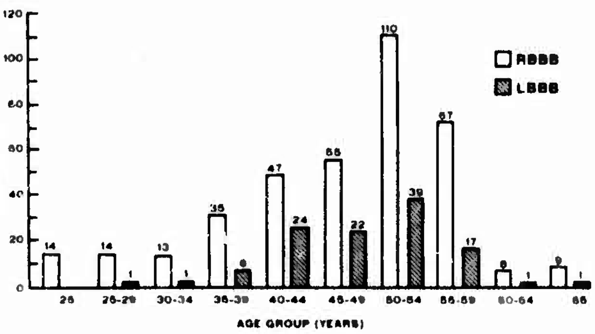

Figure 2

Age distribution at time of follow-up. RBBB in light bars, LBBB in hatched bars. The number of patients within each age group is presented above the bars.

Table 5

Subgroup Analysis of Follow-up Evaluation in RBBB Subjects

	Total	New CHD N	New HVD N	Dead N
Normal axis	226	15	11	8
Indeterminate axis	41	1	3	3
Right axis <120°	54	2	4	2
Right axis >120°	17		1	
Simple left axis	8	1	1	
Left anterior hemiblock	19	1	1	
1° A-V block	7	1		1
N	372	21	21	14
(%)		(6)	(6)	(4)

See table 3 for abbreviations.

Table 6

Subgroup Analysis of Follow-up Evaluation in LBBB Subjects

	Total	New CHD	New HVD	Dead
Normal axis	90	5	6	6
Left axis deviation	21	1	1	2
1° A-V block	3	—	—	1
N	114	6	7	9
(%)		(5)	(6)	(8)

See table 3 for abbreviations.

Table 7

Analysis of RBBB Subjects Who Died During Follow-up Period

Age at diagnosis (years)	Subgroup	Initial evaluation	Follow-up period (years)	Age at death (years)	Cause of death
46	Normal axis	Normal	10	56	Brain tumor
26	Normal axis	Normal	10	36	Auto accident
43	Normal axis	Normal	7	50	Lung tumor
41	Normal axis	HVD, CHD	10	51	Myocardial infarction
33	Normal axis	HVD	3	36	Accidental poisoning
38	Normal axis	Normal	3	41	Aircraft accident
43	Normal axis	Normal	3	46	Unknown
32	Normal axis	Normal	2	34	Aircraft accident
39	Ind axis	Normal	6	45	Auto accident
24	Ind axis	Normal	11	35	Aircraft accident
35	Ind axis	Normal	9	44	Myocardial infarction
41	RAD <120°	Normal	11	52	Accident
17	RAD <120°	Normal	1	18	Auto accident
54	1° AVB	CHD	14	68	Cor pulmonale

diomyopathy, one of complications of cardiac catheterization, and for two, the cause of death was unknown (table 8).

Dizziness or syncope related to possible further electrical dysfunction of the heart occurred in two patients with RBBB and one with LBBB. The two RBBB patients had syncopal episodes at ages 55 and 50, five and eight years after the diagnosis of RBBB. Both patients had normal initial evaluations. In one patient, complete heart block was documented and led to permanent pacemaker implantation. This patient had RAD +90° to +120° and 1° AVB associated with his RBBB. The other patient had one syncopal episode, which on thorough investigation did not indicate heart block. This patient, who had RAD +90° to +120° associated with RBBB, is alive one year after his episode of syncope and remains asymptomatic. The single LBBB patient had a permanent pacemaker inserted during hospitalization after an episode of syncope which occurred with an acute myocardial infarction and complete heart block. This patient had coronary heart disease initially diagnosed at the time he developed LBBB.

Discussion

The majority of clinical studies noted in the literature dealing with the prognosis in subjects with bundle branch block portray an ominous outlook. The main reason for this prognosis is that these reports usually come from a hospital-based population of generally ill patients. Graybiel and Sprague[5] reviewed 395 cases with bundle branch block; most had coronary or hypertensive vascular disease. In their report, 118 cases had congestive heart failure; 59, angina pectoris; and 12, Stokes-Adams syncope. A follow-up of 77% of the total group revealed 223 fatal cases, with an average life duration of 14 months. Schrienivas et al.[6] evaluated 281 cases of RBBB and noted that the prognosis was related to the presence and degree of cardiac disease. The worst prognosis in this series was for patients with coronary and rheumatic heart disease; the longest survival was for patients with no

Table 8

Analysis of LBBB Subjects Who Died During the Follow-up Period

Age at diagnosis (years)	Subgroup	Initial evaluation	Follow-up period (years)	Age at death (years)	Cause of death
36	Normal axis	Normal	12	48	Myocardial infarction
38	Normal axis	HVD	7	45	CHD
40	Normal axis	HVD	5	45	Myocardial infarction
45	Normal axis	Normal	5	50	Myocardial infarction
50	Normal axis	Normal	<1	50	Cardiac cath
40	Normal axis	CHD	10	50	Myocardial infarction
37	LAD	Cardiomyopathy	5	42	Sudden death
32	LAD	HVD	14	46	Unknown
40	1° AVB	Normal	5	45	Unknown

defined etiology for the bundle branch block. Perera et al.[4] studied 104 cases of RBBB. Of 91 cases with adequate follow-up, one-third had died over a mean follow-up period of four years. Over 95% of their patients had some form of heart disease. In the same study, a group of 60 cases with LBBB were evaluated; 60% were dead at one year of follow-up. Messer et al.[7] noted in a review of their hospitalized patients with bundle branch block that the mean survival for 281 RBBB and 555 LBBB cases was 3.9 and 3.3 years respectively. Campbell[9] followed 50 patients with bundle branch block (48 had some form of cardiovascular disease): 39 patients died, with a mean survival of two years.

A few papers have dealt with subjects with bundle branch block who were derived from an outpatient population or who had this defect discovered on routine examinations.[8, 10, 11, 13-15, 18-22] In 64 cases of RBBB, Wood et al.[8] found 35 with absent or minimal heart disease; 22 of these 35 cases remained asymptomatic over a two to 11 year follow-up period. Reush and Vivas[15] found that only three of 38 subjects with RBBB and no diagnosed heart disease died during seven years of evaluation. Smith et al.[13] studied 24 naval aviators with acquired bundle branch block who were asymptomatic and had no evidence of cardiovascular disease. They concluded that acquired bundle branch block is "frequently associated with a good prognosis in the asymptomatic patient." In a mortality study on bundle branch block, Rodstein et al.[11] present a group of individuals who were initially evaluated for purposes of insurability. They found that the survival of the group without definite evidence of cardiovascular disease was "remarkably good." Furthermore, they did not observe a "considerable" difference in mortality statistics when comparing the RBBB to the LBBB subjects.

This review of the literature coupled with the present study elucidates the fact that the prognosis of individuals with bundle branch block is significantly determined by the presence or absence, and the degree, of associated cardiovascular disease.

The present study did not find a difference for morbidity of cardiovascular disease at time of diagnosis of bundle branch block or during the follow-up period between the ECG subgroups discussed; follow-up mortality also did not differ. Thus, within the age limits of this study, the presence of unifascicular (RBBB with normal axis) or bifascicular (RBBB and LAH or LBBB) block did not affect prognosis. Though the prevalence of coronary heart disease and hypertension was significantly higher in the LBBB group, no significant differences were noted between the RBBB and LBBB groups with regard to follow-up morbidity or mortality.

The etiologic factors involved in subjects with BBB and no clinically apparent cardiovascular disease may be important with regard to development of further electrical dysfunction leading to complete heart block. A number of processes can be postulated as possible etiologic factors. In the younger population of RBBB patients, a disruption of this fascicle may have been present from birth, but no data is available relating to the incidence of RBBB in normal and healthy infants.[23, 24] It is important here to note that though the incidence of both RBBB and LBBB increases with age, the incidence of RBBB below the age of 40 is eight times more frequent than LBBB.[21, 22] Furthermore, it is unusual to find an individual below the age of 30 with LBBB. In the present study, there were 100 patients in the RBBB group below age 30, compared to only 12 in the LBBB group. Thus, in view of the rarity of LBBB in younger subjects and the knowledge that the majority of patients in the LBBB group had acquired their conduction defect, a congenital etiology would indeed be unusual for subjects with LBBB.

A clinically inapparent episode of myocarditis with residual impairment of intraventricular conduction may be an etiologic factor in both right and left bundle branch block subjects.[25, 26] Two points support this hypothesis: first, the majority of patients in the present series with acquired bundle branch block gave a history of a prolonged flu-like illness in the year preceding their ECG abnormality; secondly, angiographic and hemodynamic data on patients with acquired right and left bundle branch block with no clinically apparent cardiovascular disease have revealed a mild diffuse abnormality of the ventricular myocardium[27, 28] manifested by elevation of left ventricular end-diastolic pressure.

In the older population, a degenerative process in or near the area of the conduction system seems to be a definite etiologic possibility.[29-33] Careful pathologic studies of the conduction system by Yater,[29] Lenegre,[31] Lev,[30] and Davies and Harris[32] have revealed that in subjects above the age of 40, isolated involvement of the conduction system by degenerative fibrotic process, without significant involvement of the myocardium or other cardiovascular disease, is an important factor leading to bundle branch conduction defects and complete heart block. It is the consensus of some cardiac pathologists that this process is a result of mechanical strain on the conduction system, leading to "microtrauma" of the proximal ramifications of the bundle branch system.[30, 33]

Finally, in the present study, silent coronary artery disease may have also played an etiologic role: significant coronary artery disease was found in three (6%) of RBBB and four (14%) of LBBB subjects who underwent cardiac catheterization.

Thus, it must be concluded that a number of

etiologic factors may be involved in the development of intraventricular conduction defects in asymptomatic subjects who are free of clinically apparent cardiovascular disease.

In the absence of cardiovascular disease, the prognosis in subjects with bundle branch block relates to whether or not further electrical dysfunction and complete heart block develop. Retrospective studies[34, 35] in patients with complete heart block have revealed that in beats of supraventricular origin, some type of unifascicular or bifascicular involvement is present in the majority of these subjects. Prospective studies in patients with RBBB and LAH have found that the risk of developing complete heart block is in the range of 10% to 16%.[2, 34, 36] A higher number of patients (21%-75%) with RBBB and left posterior hemiblock are at risk for developing complete heart blocks.[3, 36] Complete heart block occurs most frequently in men between 50 and 80 years of age. In the present study, only two patients had documented complete heart block, and in only one did syncope and complete heart block occur in the absence of cardiovascular disease. Some subjects with accidental deaths and some lost to follow-up, especially in the LBBB group, could have developed and/or possibly expired from the consequences of complete heart block; nevertheless, within the age limits of the present study, the risk of developing further electrical dysfunction was extremely low. A continued follow-up evaluation of the present population may identify a greater number who will develop further electrical dysfunction; it may also help to predict a high risk group for development of complete heart block.

On the basis of this and previous studies on asymptomatic subjects with bundle branch block, certain criteria have evolved for the return of aircrew members, grounded because of ECG abnormalities, to flying status. A number of USAF subjects with RBBB or LBBB have been maintained on flying status (after a thorough cardiovascular evaluation that included hemodynamic, angiographic, and more recently, electrophysiologic studies) in the absence of objective evidence of cardiovascular disease.[27, 28] We feel that this type of thorough evaluation is necessary to identify aircrew members who are at low risk for sudden incapacitation.

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